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The purpose of this research was to develop and test a minority fill-rate component for the Marine Corps' program management module, which governs the allocation of recruits to enlisted program guarantees within the Automated Recruit Management System (ARMS). Marine Corps policy directives were used to formulate experimental forms of the utility model component. The resulting component was tested by simulating recruit assignments and assessing model performance characteristics. The results of assignment by model (ABM) were compared to actual assignment (AA) results. In 82

percent of the cases, the ABM procedure achieved superior results; namely, the minority proportion achieved under ABM was closer to that desired by Marine Corps managerial personnel than that achieved under AA.

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MINORITY FILL-RATE COMPONENT FOR MARINE CORPS RECRUIT CLASSIFICATION: DEVELOPMENT AND TEST

NAVY PERSONNEL RESEARCH
AND
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NPRDC TR 84-46

July 1984

MINORITY FILL-RATE COMPONENT FOR MARINE CORPS RECRUIT CLASSIFICATION: DEVELOPMENT AND TEST

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FOREWORD

The purpose of this research, which was conducted under project CF63-521-080-101-04.26 (USMC Optimal Classification Procedures), was to develop and test a minority fill-rate component for the Marine Corps' program management (PM) module. The PM module governs the allocation of recruits to enlistment program guarantees within the Marine Corps' Automated Recruit Management System (ARMS).

Research results are intended for program managers within the Marine Corps (MPI-40), as well as for Department of Defense researchers involved in developing personnel allocation systems.

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SUMMARY

Problem

Marine Corps recruiting service personnel are often faced with the problem of allocating a small number of program (school) guarantees in an equitable fashion among minority and nonminority recruit applicants. A decision aid in the form of a computer program was needed to assist recruiting service personnel to achieve the allocation balance across programs called for by Marine Corps policy makers.

Purpose

The purpose of this research was to design, construct, and test a minority fill-rate component to fit within the program management (PM) module of the Marine Corps' Automated Recruit Management System (ARMS).

Approach

Marine Corps data were used to formulate a utility model component. The experimental form was tested in a simulation procedure using Marine Corps accession data. Results were evaluated and compared to actual Marine Corps assignments.

Results

Assignment by model (ABM) and actual assignment (AA) results were compared. The objective of the two procedures was to assign persons so that the desired proportion of minority group members was achieved within each enlisted guarantee program. In 82 percent of the cases, the minority proportion achieved under ABM was closer to that desired by Marine Corps policy makers than that achieved under AA.

Conclusions

The operation of the component in a simulated assignment procedure resulted in personnel allocation that was in closer accord with Marine Corps policy objectives than the actual assignment procedure.

Recommendations

It is recommended that Marine Corps recruiting service personnel incorporate the minority fill-rate component within the ARMS PM module.

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INTRODUCTION

Problem

Marine Crops recruiting service personnel are often faced with the problem of allocating a small number of program (school) guarantees in an equitable fashion among minority and nonminority recruit applicants. A decision aid in the form of a computer program was needed to assist recruiting service personnel to achieve the allocation balance across programs called for by Marine Corps policy makers.

Background

Guaranteeing fair treatment for minority group members is a national problem that has received considerable attention in recent years. Bias in personnel assignment can lead to limited training opportunities and, subsequently, to limited job options. A mechanism that allocates persons to jobs in accordance with Marine Corps equal opportunity objectives is directed toward assuring fair treatment. Northrup, DiAntonio, Brinker, and Daniel (1979) state:

> Progress has been made in recent years to distribute minorities proportionately across occupations. Yet much of the work needed to solve the tougher problems of proportionate occupational distribution remains. Historically, minorities have been relegated to the so-called soft-skill occupations. Without affirmative action measures, the services cannot hope to achieve a more balanced composition within the foreseeable future. (p. 98)

In 1982, Marine Corps officers within MPI-40 directed that a classification model be developed based on the Air Force Procurement Management Information System (PROMIS) model (Ward, Haney, & Pina, 1978) and the Navy's CLASP (Classification and Assignment within PRIDE (for Personalized Recruiting for Immediate and Delayed Enlistment)) model (Kroeker & Rafacz, 1983). Among the objectives to be achieved was the allocation of training school opportunities among minority and nonminority applicants in an equitable manner.

Both the Navy and the Marine Corps have frequently used enlistment options and assignment quarantees as inducements to join the services, primarily because of the strong competition for highly qualified individuals between civilian and military institutions. During 1981 and 1982, approximately 45 percent of the total Marine Corps recruit accessions were enlisted under the provisions of an enlisted guarantee program (see Table 1);[1] and 55 percent, under an open-contract option. Individuals who enlist under an open-contract option are assigned to an occupational speciality at boot camp. The assignment decision is based on the needs of the service, the recruit's aptitude and other qualifications, and, to a lesser degree, the recruit's occupational preferences.

Objective

The objectives of this effort were to (1) design and construct a minority fill-rate component to fit within the Marine Corps' Automated Recruit Management System's (ARMS) program management (PM) module, (2) test the operation of the component in a

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[1]Personal communication with Major R. Carter, MPI-40, November 1983.

simulated assignment procedure, and (3) compare the simulation results with typical results from the present allocation procedure. The effort was conducted within the framework of the ongoing classification and assignment process. Information concerning actual assignment of recruits, minority group membership, and recruit test scores was obtained from routinely collected Marine Corps records.

Table 1

Marine Corps Enlisted Guarantee Programs

Code	Program Title
A5	Avionics
AA	Aviation Ordnance
AB	Support/Administration/Anti-air Warfare
AC	Technical Support
AD	Aircraft Maintenance
G2	Personnel Administration
G3	Motor Transport Operator
G6	Food Service
G7	Computer Operations
G8	Military Police/Correction Specialist
ZD	Combat Support
ZE	Administrative
ZF	Logistic, Supply, Transportation, Repair Services, Disbursing and M.C. Exchange
ZG	Mechanical/Electrical
ZH	Combat
ZJ	Infantry
ZK	Radio Communications
ZL	Electronics

APPROACH

Marine Corps Requirements

After discussions with Marine Corps officials, it was decided that (1) the allocation model should be developed using an algorithm similar to that used in the PROMIS and CLASP systems, and (2) the minority component should reflect the utility of a person-job match at any specific moment in the recruiting period and should incorporate an information feedback function concerning the minority fill percentage of any given program.

Sample

The sample used in this study consisted of all recruits who entered the Marine Corps between July 1981 and March 1982. This data set was the most current one available and was representative of recruits now entering the Marine Corps. Out of the total number of 8,598 recruit data records, 6,605 were used in the study. The remaining records were

for recruits who required waivers, and, therefore, exceptional consideration. Table 2 shows the restricted and unrestricted sample sizes of the recruit cohorts grouped by month.

Table 2

Marine Corps Recruit Sample Sizes

Recruit Entry Period	Restricted Sample	Unrestricted Sample
July 1981	542	674
August 1981	774	887
September 1981	808	952
October 1981	766	952
November 1981	783	1,054
December 1981	689	971
January 1982	906	1,288
February 1982	815	1,078
March 1982	522	742
Total	6,605	8,598

Personnel Allocation Procedure

The Marine Corps ARMS and the relationship between this system and the Training Input Plan (TIP) were analyzed to determine the steps to be taken in developing the allocation model. In addition, Marine Corps officials involved in recruiting, training, and assigning recruits were interviewed to obtain background information for use in developing the allocation algorithm, a modification of the process used in CLASP (Kroeker & Rafacz, 1983).

System flow charts were prepared and an allocation computer program was developed. The system development plan required that each component to be included in the allocation model should be designed in modular form to facilitate component integration.

Minority Component Development

After discussions with Marine Corps officers (MPI-40), it was determined that the utility value calculation should operate as a time-dependent function that reflected the difference between a program's minority-fill proportion and its target proportion. The term should add or subtract utility points for a given person-program match, depending upon the minority-fill proportion of the program. For example, if the minority-fill proportion was below the desired target value for a particular program, utility points should be added to increase the likelihood of assigning a recruit to the program. Figure 1 shows the feedback characteristics and an abbreviated form of the component logic.

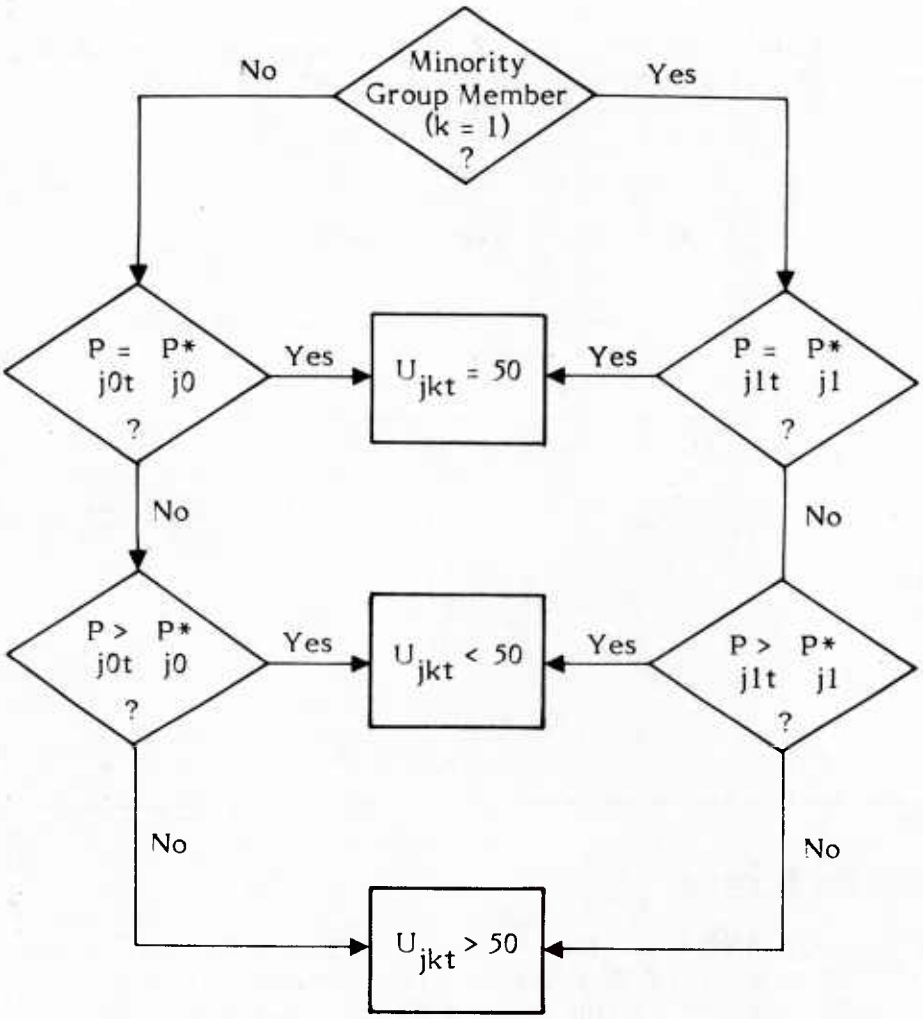

Figure 1. Minority component flow diagram.

The statistic that measures the degree to which a given program's minority-fill proportion differs from the desired proportion is expressed as

$$P_{jkt} - P^*_{jk} \tag{1}$$

where

P_{jkt} is the fill proportion within job j, for group k, at time t,

k is an indicator variable such that k = 1 for a minority applicant and k = 0 otherwise, and

P^*_{jk} is the desired group fill proportion for job j and group k.

To calculate minority component utility values, a scaling constant (Q) was estimated empirically by observing minority balance discrepancies in a simulated assignment procedure. Since the objective of the minority component was to allocate persons so that the desired proportion of minority group members was achieved within each program, it was important to define a discrepancy statistic Δ_{jkt} as follows:

$$\Delta_{jkt} = P_{jkt} - P^*_{jk} \tag{2}$$

A discrepancy mean square statistic is calculated for a person assigned at time t as follows:

$$Q_t^2 = \frac{\sum_{j=1}^{18} w_{jt} \Delta^2_{jkt}}{\sum_{j=1}^{18} w_{jt}} \tag{3}$$

where w_{jt} is the number of vacancies within program j at time t.

The simulated assignments of personnel within each sample yielded a distribution of Q_t values. Since each distribution exhibited considerable skewness, the median was chosen to represent the Q parameter. The overall average of the resulting Q values was 0.086.

The utility equation based on the above statistics is shown as

$$U_{jkt} = 50.0 + 10 \frac{P_{jkt} - P^*_{jk}}{Q} \tag{4}$$

where

U_{jkt} is the utility value associated with the allocation of person i to job j.

Simulating Recruit Assignments

A computer program was developed to simulate the assignment of recruits to enlisted guarantee programs. The program logic underlying the simulated allocation procedure followed the algorithm derived by Ward et al. (1978) and resembled that used for CLASP assignment (see Folchi, Rafacz, Kroeker, & Warner, 1982). It allowed for the optimal-sequential allocation (Kroeker & Rafacz, 1983) of recruits one at a time. Recruits who were unable to meet minimum Marine Corps program qualifications (i.e., those requiring waivers) were excluded from the simulated allocation process.

The allocation process was driven by the minority utility component described above. In other words, the utility of assigning recruits to enlisted guarantee programs was determined by equation (4).

Each of the 6,605 recruits in the sample was assigned to an enlisted guarantee program using the allocation model. The quality of these assignments was then compared to actual assignments.

RESULTS AND DISCUSSIONS

Utility Model

The model consisted of a single utility component; namely, the minority fill-rate utility generator. The classification procedure operated on a payoff matrix containing numerical utility values. This matrix expressed the value to the Marine Corps of assigning a specific recruit to a specific program.

The decision index (DI) allocation algorithm used by the system has been described in Kroeker and Rafacz (1983) and Ward (1959).[2] To facilitate comparisons among program options, DI values were transformed to a scale with a mean of 50 and a standard deviation (SD) of 20. In a further transformation, the value 100 was assigned to the most optimal program for a given recruit. The score resulting from these transformations was called an optimality index (OI).

Assignment Simulation Results

A separate simulation exercise was conducted using recruit data from each of the recruiting months--beginning with July 1981 and ending with March 1982. Each simulation resulted in the calculation of average OI values for all enlisted guarantee programs. Table 3, which shows the average OI values for July 1981, shows that they range from a low of 58.2 for program ZD to a high of 95.0 for program G7. To a large extent, the differences between the OI averages reflect arbitrary influences of time-of-entry into the service. In other words, the distribution of minority and nonminority group members in the entry queue affects the magnitude of the resulting program averages. Table 4 provides a summary of the assignment simulation results for all recruiting months.

Comparison of Two Allocation Procedures

Assignment by model (ABM) and actual assignment (AA) results were compared. The objective of the two allocation procedures was to assign persons so that the desired proportion of minority group members was achieved within each enlisted guarantee program. For example, for July 1981, it was desired that a minority proportion of 0.206 be achieved within each program.

Table 5, which displays the minority proportions achieved under each allocation procedure as well as the deviation from the desired proportion, shows that the minority proportion achieved under the ABM procedure is closer to the desired proportion than that achieved under the AA procedure. The absolute values of entries in column 4 of Table 5 are most often smaller than those in column 5. For example, for July 1981, the weighted average[3] of column 4 absolute values is 12.6 percent, compared to 44.2 percent for column 5.

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[2] A DI score reflects the degree of expected proficiency resulting from a particular person-job match (Ward, 1959).

[3] Monthly program sample sizes constituted the weights used.

Table 3

Average Optimality Indices (OIs) for Enlisted Guarantee Programs
July 1981

Program[a]	Average OI
A5	92.6
AA	73.9
AB	74.8
AC	89.9
AD	65.2
G2	82.2
G3	67.5
G6	67.6
G7	95.0
G8	92.5
ZD	58.2
ZE	77.8
ZF	62.5
ZG	62.5
ZH	66.1
ZJ	59.3
ZK	64.3
ZL	92.7

[a]Titles are provided in Table 1.

Table 4

Average Optimality Indices by Month

Recruiting Month	Average[a] OI	Smallest Program Mean	Largest Program Mean
July 1981	66.8	58.2	95.0
August 1981	73.3	38.5	97.9
September 1981	63.8	44.0	94.0
October 1981	78.2	62.0	98.8
November 1981	67.7	54.0	100.0
December 1981	69.6	56.3	99.0
January 1982	55.5	39.5	96.6
February 1982	74.5	64.6	100.0
March 1982	83.4	63.9	100.0

[a]Program OI means were weighted by corresponding sample sizes.

Table 5

Minority Proportions Achieved Under Two Allocation Procedures

Enlisted Guarantee Program[a,b]	Assigned By Model (ABM)	Actual Assignment (AA)	Deviation From Desired Proportion (%) Model	Actual
July 1981 (desired proportion = 0.206, N = 542)				
A5*	.143	.105	- 31	- 49
AA*	.143	.286	- 31	39
AB*	.207	.208	0	1
AC*	.143	.286	- 31	39
AD*	.188	.111	- 9	- 46
G2*	.250	.444	21	116
G3*	.196	.133	- 5	- 35
G6*	.182	.143	- 12	- 31
G7	.000	.250	-100	21
G8*	.200	.100	- 3	- 52
ZD*	.189	.068	- 8	- 67
ZE*	.192	.429	- 7	108
ZF*	.186	.321	- 10	56
ZG	.183	.219	- 11	6
ZH*	.191	.043	- 7	- 79
ZJ*	.224	.057	9	- 73
ZK	.186	.194	- 10	- 6
ZL	.143	.190	- 31	- 8
Average			12.6	44.2
August 1981 (desired proportion = 0.198, N = 744)				
A5	.000	.071	-100	- 64
AA*	.200	.048	1	- 76
AB*	.200	.333	1	68
AC*	.176	.045	- 11	- 77
AD*	.200	.154	1	- 22
G2*	.208	.476	5	141
G3*	.172	.123	- 13	- 38
G6*	.200	.316	1	60
G7*	.000	.500	-100	153
G8*	.231	.000	17	-100
ZD*	.152	.127	- 23	- 36
ZE*	.204	.326	3	65
ZF*	.174	.317	- 12	60
ZG*	.167	.116	- 16	- 41
ZH*	.190	.222	- 4	12
ZJ*	.182	.034	- 8	- 83
ZK*	.200	.273	1	38
ZL*	.200	.157	1	- 21
Average			11.0	53.8
September 1981 (desired proportion = 0.181, N = 808)				
A5*	.111	.042	- 39	- 77
AA*	.182	.080	1	- 56
AB*	.211	.235	16	30
AC*	.154	.034	- 15	- 81
AD	.143	.167	- 21	- 8
G2*	.132	.250	- 27	38
G3*	.146	.141	- 19	- 22
G6*	.179	.158	- 1	- 13
G7	.000	.000	-100	-100
G8*	.185	.231	2	28
ZD*	.149	.118	- 18	- 35
ZE*	.164	.222	- 9	23
ZF*	.186	.328	3	81
ZG*	.164	.146	- 9	- 19
ZH*	.167	.125	- 8	- 31
ZJ*	.181	.067	0	- 63
ZK*	.144	.133	- 20	- 26
ZL	.125	.140	- 31	- 23
Average			12.6	44.0

[a] Titles for programs are provided in Table 1.

[b] An asterisk after a program indicates that the proportion under ABM is closer to the desired proportion than the proportion under AA.

Table 5 (Continued)

Enlisted Guarantee[a,b] Program	Assigned By Model (ABM)	Actual Assignment (AA)	Deviation From Desired Proportion (%) Model	Actual
October 1981 (desired proportion = 0.204, N = 766)				
A5	.125	.161	- 39	- 21
AA	.111	.208	- 46	2
AB*	.185	.250	- 9	23
AC	.125	.137	- 39	- 33
AD*	.200	.056	- 2	- 73
G2*	.200	.321	- 2	58
G3*	.195	.189	- 4	- 7
G6	.222	.200	9	- 2
G7*	.250	.125	23	- 39
G8*	.200	.069	- 2	- 66
ZD*	.197	.082	- 4	- 60
ZE*	.182	.449	- 11	120
ZF*	.196	.291	- 4	43
ZG*	.208	.225	2	10
ZH*	.194	.091	- 5	55
ZJ*	.188	.075	- 8	- 63
ZK*	.195	.221	- 4	8
ZL	.100	.161	- 51	- 21
Average			13.2	37.2
November 1981 (desired proportion = 0.176, N = 783)				
A5*	.182	.053	3	- 70
AA*	.143	.000	- 19	-100
AB	.159	.167	- 10	- 5
AC*	.125	.109	- 29	- 38
AD*	.144	.118	- 18	- 33
G2*	.146	.395	- 17	124
G3*	.170	.206	- 3	17
G6*	.158	.000	- 10	-100
G7	.100	.100	- 43	- 43
G8*	.152	.033	- 14	- 81
ZD*	.154	.081	- 13	- 54
ZE*	.148	.206	- 16	17
ZF*	.174	.220	- 1	25
ZG*	.154	.200	- 13	14
ZH	.136	.200	- 23	14
ZJ*	.167	.079	- 5	- 55
ZK*	.143	.225	- 19	28
ZL*	.125	.077	- 29	- 56
Average			14.3	40.6
December 1981 (desired proportion = 0.161, N = 689)				
A5*	.143	.098	- 11	- 39
AA*	.125	.000	- 22	-100
AB*	.154	.203	- 4	26
AC	.143	.156	- 11	- 3
AD*	.161	.129	0	- 20
G2*	.182	.188	13	17
G3*	.167	.091	4	- 44
G6*	.167	.333	4	107
G7*	.167	.083	4	- 48
G8	.140	.154	- 13	- 4
ZD*	.167	.000	4	-100
ZE*	.149	.386	- 7	140
ZF*	.162	.182	1	13
ZG*	.158	.132	- 2	- 18
ZH*	.179	.333	11	107
ZJ*	.161	.000	0	-100
ZK*	.139	.189	- 14	17
ZL*	.133	.286	- 17	78
Average			6.2	39.6

[a]Titles for programs are provided in Table 1.

[b]An asterisk after a program indicates that the proportion under ABM is closer to the desired proportion than the proportion under AA.

Table 5 (Continued)

Enlisted Guarantee[a,b] Program	Assigned By Model (ABM)	Actual Assignment (AA)	Deviation From Desired Proportion (%) Model	Actual
January 1982 (desired proportion = 0.170, N = 906)				
A5*	.150	.067	- 12	- 61
AA*	.125	.000	- 27	-100
AB*	.149	.200	- 12	18
AC*	.154	.024	- 10	- 86
AD*	.136	.098	- 20	- 42
G2*	.143	.432	- 16	154
G3*	.145	.070	- 15	- 59
G6*	.152	.000	- 11	-100
G7*	.176	.000	4	-100
G8*	.145	.077	- 14	- 55
ZD*	.176	.150	4	- 12
ZE*	.147	.316	- 14	86
ZF*	.143	.292	- 16	72
ZG*	.143	.207	- 16	22
ZH*	.167	.000	- 2	-100
ZJ*	.183	.073	8	- 57
ZK	.146	.158	- 14	- 7
ZL	.154	.158	- 10	- 7
Average			13.9	52.0
February 1982 (desired proportion = 0.163, N = 815)				
A5*	.125	.051	- 23	- 69
AA	.000	.000	-100	-100
AB*	.136	.214	- 16	31
AC	.071	.086	- 56	- 47
AD*	.130	.115	- 20	- 29
G2*	.136	.292	- 16	79
G3*	.148	.073	- 9	- 55
G6*	.103	.100	- 37	- 39
G7*	.125	.000	- 23	-100
G8*	.140	.020	- 14	- 87
ZD*	.131	.024	- 20	- 85
ZE*	.136	.368	- 16	126
ZF*	.133	.258	- 18	58
ZG	.131	.133	- 20	- 18
ZH*	.136	.000	- 16	-100
ZJ*	.160	.000	- 2	-100
ZK*	.128	.237	- 22	46
ZL	.125	.136	- 23	- 16
Average			19.8	58.8
March 1982 (desired proportion = 0.162, N = 522)				
A5	.000	.022	-100	-87
AA	.000	.000	-100	-100
AB*	.145	.239	- 10	48
AC*	.071	.059	- 56	- 64
AD*	.135	.057	- 17	- 65
G2*	.143	.412	- 12	154
G3*	.174	.188	7	16
G6*	.190	.125	18	- 23
G7	.154	.154	- 5	- 5
G8*	.139	.109	- 14	- 33
ZD*	.143	.091	- 12	- 44
ZE*	.143	.323	- 12	99
ZF*	.143	.333	- 12	106
ZG	.145	.177	- 11	10
ZH*	.133	.333	- 18	106
ZJ*	.191	.043	18	- 73
ZK*	.139	.200	- 14	24
ZL	.067	.143	- 59	- 12
Average			24.9	53.2
Overall average			14.2	47.1

[a]Titles for programs are provided in Table 1.

[b]An asterisk after a program indicates that the proportion under ABM is closer to the desired proportion than the proportion under AA.

CONCLUSIONS

The operation of the component in a simulated assignment procedure resulted in personnel allocation that was in closer accord with Marine Corps policy objectives than was the actual assignment procedure. For example, the average deviation from the desired minority proportion under ABM was 14.2 percent, compared to 47.1 percent under AA. Further, the deviation from the desired proportion was less under ABM than under AA for 82 percent of the cases.[4]

RECOMMENDATIONS

It is recommended that Marine Corps recruiting service personnel incorporate the minority fill-rate component within the PM module.

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[4]It should be noted that factors other than minority considerations were used during the AA procedure, thus making an interpretation of the above results more difficult.

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